

EXHIBIT 47

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The man who invented the first self-driving motorcycle is leading Uber into the future



BIZ CARSON

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The first self-driving vehicle Anthony Levandowski built ended up in the Smithsonian.

But it's not going to be the only time the California-based engineer will create history. In the last 13 years, Levandowski has watched the self-driving car industry go from crazy motorcycle challenges to pizza deliveries to a real thing that is going to change the future of the world.



Uber CEO Travis Kalanick with Uber's new VP of Engineering, Anthony Levandowski

Associated Press

"Just like the natural evolution of the horse and buggy was the car. This is the next thing," Levandowski said. "I really do think the most important thing that computers are going to do in the next 10 years is drive cars."

One of the pioneers of autonomous vehicles, Levandowski was the brains behind much of Google's self-driving efforts. He left Google last year to create his own startup, Otto, which retrofits trucks to make them autonomous. Three months after its public debut, Otto was bought by Uber in exchange for 1% of the company — a deal valued at nearly \$680 million. Plus they get a 20% cut of all future profits from the trucking division.

Now, Levandowski runs both the self-driving car and trucking divisions at Uber and is the man in charge of a bet that Uber's CEO Travis Kalanick says the company can't afford to lose.

Business Insider talked with Levandowski about what it was like to be at the beginning of the self-driving car industry — and how it's going to change the future as we know it. *The following Q&A has been lightly condensed and edited for clarity.*

Biz Carson: Before you started running the self-driving car show at Uber and before Google, you'd already had an interest in self-driving vehicles. But you didn't start with a car. How did you get into this — and why even start with a motorcycle?

Anthony Levandowski: In 2003, my mom actually gave me a call, which is funny because she works at the European Union in Brussels, Belgium, and let me know that there's a cool competition with robots across the desert. And I thought this was definitely something I wanted to be a part of. This was the [first DARPA Grand Challenge](#).

A friend of mine, Randy Miller and I, we went to their first conference describing what they were thinking of doing. It was described basically as a race from L.A. to Vegas, across the mountains and across the desert. And on the drive back from L.A., a motorcycle kinda passed us on Highway 5. It was clearly faster than all the cars and more nimble, and it can lane split. And we were like "Wow, there's your answer. A motorcycle is clearly going to be faster in off-road terrain than a car or truck or SUV, whatever you want."

That was a mistake. I learned a lot, but I would not recommend anybody for doing self-driving motorcycles anytime soon. It's just really hard. We spent a year to make the technology work so that we could drive 20 feet. That's something you can do in like one day if you go straight to a car.

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Carson: So when you were working on the self-driving motorcycle, it was more of a fun challenge. Was there a moment when you realized that this was going to change how everyone's driving or that in 10 years there will be self-driving taxis going around Pittsburgh? What did you make of it all back in 2003?

Levandowski: When we got the tech kind of finally working, "working" is in quotes because there was a lot of things that were missing, but working well enough that it would go, it was kind of a very special moment. It was realizing "Wow, this is going to work."

Things are becoming alive. The motorcycle is able to do things on its own. I don't have to babysit it. And by things, it's like drive on the road on its own, it could turn, it could come around, stuff like that.



The "Ghostrider" robot motorcycle on display at the Smithsonian.

Smithsonian

The day of the race, even at the qualifying event, when you saw all of these people getting there cars kind of working, you could really feel there was something special about “Wow, it would be really cool if a car could show up and drive somewhere.”

It wasn't clear at the time that it would be in a ride-sharing situation. It kind of felt more at the time it would be package delivery, like your pizza gets delivery by a robot kind of thing. Which is why a couple years later, in 2008, I built a robot that delivered a pizza from downtown San Francisco to Treasure Island. And that was really cool. That really kind of cemented that this is super interesting. It's kind of the equivalent of going up the elevator instead of walking up the stairs. You can kind of have a magic carpet that takes something somewhere for you.

Carson: Between 2003 and 2008, you joined Google but not to work on self-driving cars at first. So after having this kind of magical moment with the motorcycle, why didn't you continue with the project?

Levandowski: I was 22 at the time when I first discovered that. So, it was hard for me to personally imagine like “Oh I'm going to make the cars that everybody in the world is going to use.” I like incremental improvements or at least seeing where you're going to go and really being able to understand what's feasible at the time.

I'd just a) had this magical moment but b) I also had a very real reminder that if you do too much it's not going to work by having the motorcycle specifically not work compared to the cars that were a lot of work.

So, I was really in the mode of focusing on let's make something that's very applicable directly. I met and talked with a fellow named Sebastian Thrun, who is now a really good friend. At the time, we were looking at how the logs from these robots are recorded and trying to figure out what the problems are. Instead of looking at it through time, we could look at it through space. So think of it as if you want to see what it looks like at this intersection, which was kind of a weird concept, we were logging the 360-degree video. So that's one way to take the problem we have and solve it right away while still being involved in something similar, or in that particular space.

Carson: So then when did you come back to the self-driving car problem? And when you did come back to the space, how much did you look ahead to say this will change cities or it will decrease how many cars are owned privately? Was that vision there from the beginning?

Levandowski: It was too early to call it the self-driving car space because there was zero people working on it. [Laughs]

After I joined Google and stopped working on robots — I'd built some self-driving tractors on farms in the meantime — I was always tinkering and playing with robots at home and just as a hobby. When we finished my second project at Google, the first was building StreetView and the second was taking the StreetView data then building out the maps database that you use on your phone to do turn-by-turn navigation for free, then this TV show came about. The producer I knew previously and he was like "Hey can you get the motorcycle out? I'd like to deliver a pizza with it."

I was like "Oh that's not the right way to deliver a pizza. And the motorcycle is in the Smithsonian and I don't think they're going to be down with me borrowing it to do a little demo and bringing it back." You don't check things out like that like a library. So he was like "Ok that's fine, but can you build something in a month to deliver the pizza?" I accepted his "challenge" and we built a car from scratch in roughly a month to drive from downtown S.F. to Treasure Island to deliver a pizza.

Now it's not as hard of a problem because we had a police escort. And they closed down the roads we were on, and we didn't have to stop for traffic lights. It's a much lower bar of work and technical capability. And we got stuck exiting on the Bay Bridge. But we ended up delivering the pizza. So that's how I got back in.



The funny part was that I asked Google being like “Hey is it ok if I can do this?” and Google was like “yeah OK have fun. We’re not in the robot car space at all. In fact, we want you to clarify that it’s not because we don’t want to have any accident or liability or any kind of issue that might come out of running a car across San Francisco with nobody in it.”

That was 2008. I got really excited about it and getting back in. It was more of a “we need to do this”.

Carson: You said the self-driving car space at that point was just you guys. Eventually Google ended up buying your company. When did others start catching on so that this become a serious business for the future than a “fun challenge” of a robot delivering pizza?

Levandowski: I think, like all big things, you don’t know they’re going to be a big thing when you start. You just kind of like play because it’s fun and it’s interesting and then it turns out to be way more important than you expected. While working at Google nobody had expectations when we started the project of where this would go. We definitely met with all the car companies and they’re like “No. This is never going to be a thing. It’s not possible, it’s not allowed.” Just all kinds of reasons why they were not willing to participate.

And then when we, I think John Markoff wrote a story, discovering that we were testing and driving the vehicles in public, that’s when all the car companies realized at the first level that something might happen. But it took many years after that getting closer and closer to the actual goal before we get to the state now where for most people, it seems like the natural evolution of the car will be a self-driving car. Just like the natural evolution of the horse and buggy was the car. This is the next thing.

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Carson: Did you have that realization at some point? Like an awakening? When did it change for you?

Levandowski: I realized there was something special when we did the pizza delivery because I hadn’t slept in a couple days, so I didn’t realize it that day, but looking at it later on it, it just works. It’s going to be amazing. When we realized it would actually be the way of people moved around in the future, I think much later.

I don’t have a specific date and time. It wasn’t on a Tuesday at 4 a.m. when I woke up and said “Oh shit.” There was nothing like that. It’s more of when you see it working without errors, even though you know the technology is not ready yet, but when you’ve seen it driving you for hours, you realize this is special.

For me, that specific moment was after we completed our first 100 -mile trip start to finish with no interventions, with no manual takeover, that this was a specific goal that we had for us. There was three of us there — Chris Urmson, Dmitri Dolgov, and myself — and after we did this, it was super powerful. We just celebrated because, wow, this car just drove from Santa Cruz to Cambria. It didn’t drive it well. It braked late in the turns and accelerated too slow afterwards. We didn’t have it all tuned well.

You could see the essence was there. The idea had been born and had been shown. From there to getting it working everywhere was just the problem of figuring out all the test cases that are broken and fixing them and not inventing new fundamental things.

Carson: What made you leave Google then and found Otto?

Levandowski: I worked there for almost 9 years and I did a lot of great things, but for me it was about my time to do my own thing. I was excited about self-driving trucks and a new company was the right place to do that. I really want to get the technology out it into the world. And doing it on trucks is probably the shortest path. There was a bunch of people who thought the same as I did and who joined me. There’s no single event, other than it was time for me to do my own things.



Otto's equipment retrofits trucks and makes them self-driving.

Darren Weaver

Carson: Why are trucks the shortest path to the future of automation in vehicles?

Levandowski: Trucks mainly drive on highways and highways are a very structured environment. Meaning, everyone's going the same direction. There's no traffic lights. There's no stop signs. There's no cross traffic. There's no pedestrians. Yet it's a very long journey, so it's monotonous. It's kind of tiring. And a human can only do so much of it. So if you're a truck driver, you're driving as much as you can, which legally for some is 11 hours. Some cheat because they have to make more money. Some cheat because they have to. Some cheat because they want to go home. At the end of the day, it's a grueling job. There's 50,000 truck driver shortage in the workforce today. The technology required to drive in the highway versus driving in the city is very different. It's maybe 20 to 50 times easier. So for us it made sense as a startup to go after a self-driving truck and bringing the trucking industry into the future. And the technology required to do that was much easier, I would say doable as a startup. Building a full-self-driving car to move passengers is much much much more ambitious and much more complicated.

Carson: Now you're in charge of both the self-driving cars at Uber and the trucking. A lot of what Uber has talked about is this future where UberPool will dominate, that you won't have as many cars privately owned, that people will be shuttered around in this self-driving, driverless future. Is that really what will be happening to the world in 20 years? It seems like we're just starting with trucks, and if that's 50 times easier, how long will this take before we get to this idealized world?

Levandowski: That's true. What I like is that all of the experiences we do while driving a car or truck counts towards making a safer and better driver. By doing trucks and cars, you're really just doing one thing, which is driving. The trucking piece is helping you drive better on highways. The car piece has its own city driving as well.

HOW UBER'S FIRST SELF-DRIVING CAR WORKS

Top mounted **LiDAR** beams 1.4 million laser points per second to create a 3D map of the car's surroundings.

There are **20 cameras** looking for braking vehicles, pedestrians, and other obstacles.

A **colored camera** puts LiDAR map into color so the car can see traffic light changes.

Antennae on the roof rack let the car position itself via GPS.

LiDAR modules on the front, rear, and sides help detect obstacles in blind spots.

A **cooling system** in the car makes sure everything runs without overheating.



SOURCE: Uber

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Skye Gould/Yu Han/Business Insider

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If you think about it, there's no good reason why you want to own your own car. Your car is about safe, effective, and reliable transportation and that's what Uber is about as well. But with a car, a lot of other things come. You can't drive it after you go out drinking with your friends. You can't drive it when you're sleepy. You have to go park it. A lot of times you have to go fill it up. You have to wash it, you have to do all kinds of maintenance.

But if you just had the right car you wanted for the right time, then all these problems kind of go away. For me, it's crystal clear that the future is shared self-driving vehicles, both cars and trucks. In 20 years, I think it will be weird for people to say "I'm getting my driver's license." There's no need for that. I have two young kids, a 2-year-old and a 6-year-old, and I just don't think they're going to get their driver's license. Uber will have the technology both on the manually-driven side and on the self-driving side that they just won't need to drive.

Carson: Well how much pushback do you think there will be from the public? To me, America sometimes is synonymous with the open road and Route 66 and this kind of freedom and individualism that comes with owning your own car and having your destiny.

Levandowski: I love that. But when was the last time you drove on route 66, or any road that resembles how a car commercial describes what owning a car is going to be like? Like never. I've never driven on any part.

Carson: I actually drove on Route 66 a few years ago when I moved across the country.

Levandowski: Ok good. I drove across the country on Highway 80 and it wasn't anything fun. We were saving money because we had to drive across the country.

Driving 90+% of the time just isn't fun. It's about transportation. It's about getting there. If when you do want to drive and it's an activity, then go do that. Enjoy it. It's great. Your stick shift car in traffic is not great. If you actually enjoy commuting in traffic every day back and forth and enjoy searching for 20 minutes for a parking space in San Francisco when you get home, then great, you should continue to do that. I'm not saying we're banning the ownership of cars. We're just giving people more freedom of choice.

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You just won't have to drive. Driving is the number one cause of fatalities in the US today. If it was a disease, it would be an epidemic. It would be out of control.

Carson: With this future though, how will cities change? And can they change fast enough to even meet the needs of self-driving vehicles?

Levandowski: Cities just react to the tools that exist today. A lot of cities were built around before there were this many cars. You can see pictures of downtown San Francisco of like trolleys, and horses and carriages and maybe a few earlier automobiles. And then they figured out how to adapt to that. I think it's the same thing with self-driving cars and Uber in general or ridesharing.

We have a cultural value that is celebrate the cities. So everything that we do that we do is about helping people get to where they want to go safely and reliably. The city itself doesn't really need to change. We're building the technology to drive what the city is today. And if by removing car ownership, maybe you don't need parking, maybe we can have parking structures that turn into parks. Maybe there's more sidewalk space. Maybe there's more bike lanes. There's all kinds of changes that can happen. I don't know what they're going to be and I think the city planners are much more equipped to deal with that than I am. But all I can say is that I'm focused on making sure this technology comes as safely and as soon as possible.

